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# PERMAFLEX

## **I. Background of the Invention**

### **A. Field of the Invention**

This application claims priority to provisional patent application, Serial No. 60/468,407, entitled Permaflex, filed May 6, 2003.

The present invention provides a new and improved versatile, permanent, flexible plastic, and overcomes certain difficulties inherent in the related inventions while providing better overall results.

## **II. Summary of the Invention**

In accordance with one aspect of the present invention, a twin screw reaction process utilizes high speed, temperature control, and sheer.

Still other benefits and advantages of the invention will become apparent to those skilled in the art upon a reading and understanding of the following detailed specification.

Having thus described the invention, it is now claimed:

## **PermaFlex Provisional Patent Application**

### Motivation and Creation:

Engineered Plastics Corporation desired to compete with thermoplastic polyester elastomers such as Arnitel (DSM), and Hytrel (Dupont). Their materials are made in reactors from monomers and polymerized to produce these polymers of hard and soft segments; polyester being the hard segment, and polyether being the soft segment.

This process is expensive to set up, dangerous to operate, and restrictive in its use, making it necessary for secondary operations, such as compounding to color, stabilize, modify, and fill. This co-monomer reaction process also limits the range of mole weights, hardness and polymers available in the initial reactor process.

Engineered Plastics Corporation wished to manufacture less expensive, higher quality thermoplastic polyester elastomers (TPE's). We have requests from potential customers for these TPE's for manufacture of tubing and hoses and other products.

Engineered Plastics Corporation combined polymers and polyesters of hard and soft nature (TPU being the soft (Exhibits E, F), and rigid polyesters PBT, PC, PET, PETG, PCT, PCTG, SA, and MUX G being the hard (Exhibits D, G-M), with plastisizers, antioxidants, UV stabilizers, release agents, and colors. With twin screw extruder processing, we were able to produce TPE's of a wide variety and a broad range of physical properties, in one step, with less capital expense, lower material costs, greater flexibility and safety, and with lower environmental impact.

Engineered Plastics Corporation's twin screw reaction process utilizes high speed, temperature control, and sheer. This is dependant on the screw length, RPM, and screw segment configuration, yielding greater efficiency. Engineered Plastics Corporation has produced these TPE's, and we have had these products then converted into finished goods experimentally.

Engineered Plastics Corporation's process success was dependent on thousands of experiments. This process, and combinations of materials, yields products far surpassing anything on the market today in performance, price and efficiency. (Exhibit N)

### Synthesis:

The synthesis of new copolymer thermoplastic elastomer esters by alloying polyester plastics with thermoplastic urethane elastomers is as follows. Novel thermoplastic polyester elastomers (TPE's) are synthesized that exhibit useful properties such as elastomeric deformation and reformation of shape under stress and relaxation, considerable elongation, high tensile, temperature resistance, compression set resistance, chemical resistance and general over-all durability.

Polyesters such as PBT, PC, PET, PETG, PCT, PCTG, SA, and MUX G, (hereby referred to as PEM) and thermoplastic polyurethane (TPU) were combined in a twin screw extruder to achieve dispersions in various ratios from 90/10 to 50/50 reciprocally on PEM to TPU. Antioxidants, third polymer modifiers, lubricants, and release agents were also added to modify physical properties, but the foundation of these compounds is PEM and TPU.

The results of these alloyed blends show solubility, miscibility and the creation of a new material. The digital scanning calorimeter (DSC) results (exhibit A) show different peaks or curves than the PEM or TPU individually (exhibit B&C). Also, the physical properties of the alloy show properties that are not found in any of the ingredients. The elongation of the (alloy) TPE 55, 50/50 bend of PEM & TPU show 800% elongation, yet the PEM = 300% elongation (exhibit D) and the TPU = 500% elongation (exhibit E), yet the alloy retains 7000 PSI tensile. Another alloy, TPE 35, 80% TPU (500% elongation) & 20% PEM (300% elongation), yield over 1100% elongation and 6000 + tensile. (The specimen did not break; 1100% is the limit of our testing machine.)

These alloys also show great stability in temperature extremes:

TPE = No break notched izod resistance @ -40° F, 73° F and 300° F

TPE = No change in tensile and elongation @ -40° F, 73° F and 300° F

PEM = brittle @ -40° F

TPU = 3 izod @ -20° F, melts @ 300°F

TPE has resistance to hydrolysis 210° F, TPU is unsuitable

The new alloy exhibits compression set resistance equal to thermoset rubbers, a wide range of hardness (depending on formulation) from 40A to 80D, and a wide range of flex modulus from rubbery to stiff.

The new alloy shows flexibility, thermoplastic processing, reusability, super durability and stability. Our initial results show resistance to chemical & UV attack.

The following graphs show the results, which further demonstrate the synthesis of the new polymer. (Exhibits O-U)

## PERMAFLEX TPE PROPERTY GUIDE

PermaFlex is the versatile, permanent, flexible plastic. Its flexibility, stability, toughness, strength and elasticity give PermaFlex millions of applications. The stability of PermaFlex allows its use in all types of demanding environments. It has tremendous resistance to attack by chemicals, solvents, weather, vapors, gases, microbes, and UV light.

PermaFlex is temperature stable with retention of all physical properties, including no-break izod and no-break dart impact, at temperatures from  $-40^{\circ}$  to  $300^{\circ}$  F, and some at up to  $375^{\circ}$  F.

The creep resistance of PermaFlex is equal to or exceeds many thermoset rubbers with as little as 10% compression set @  $100^{\circ}$ C for 72 hours.

The electrical resistance of PermaFlex makes it a perfect insulator, yet it can be modified to be anti-static or conductive.

PermaFlex is tougher than rubber or other plastics, and is resistant to abrasions, scratches, cuts and tears.

The flex and elasticity of all grades of PermaFlex makes its durability outstanding. The flex modulus of the product range from rubbery to rigid or 2,000 to 300,000 PSI for unfilled products. All grades are flexible for millions of cycles and are still testing after 1000's of hours.

PermaFlex elasticity and tensile modulus are unrivaled. It has up to 8000 PSI tensile and over 1600% elongation with tensile modulus of 5000+ from 100% elongation to 1000% elongation. PermaFlex ranges in durometer from 35 to 75 D at this time, but softer and harder versions are coming.

PermaFlex is made with all FDA approved ingredients.

PermaFlex is easily processed by injection molding, extrusion, blow molding, or thermoforming. (See process guide.)

Uses include film, fibers, adhesives, packaging, and modifiers for plastic, asphalt, tar and oil. Also for transportation, appliances, house wares, construction, safety, agricultural and farming, apparel, toys, lawn and garden, military, medical, furniture, marine, sporting goods, tools, utilities, communications, textiles and industrial.

### Uses:

- ◆ Optical media – For example, CD, DVD, CDR, CDRW, minidisk, VCD, all other forms of digital optical media. Eyewear – Glasses, lenses, sunglasses, safety glasses, screens.
- ◆ Transportation – Interiors, instrument panels, bolsters, bezels, boxes, covers, holders, knobs, pedals, rests, ducts, lenses, glazing, and trim. Exterior – hubcaps, body parts, bumpers, panels, doors, hoods, fenders, lights, and trim.
- ◆ Appliances – Housings, panels, displays, bins, trays, covers, boards, bases, bezels, fans, coffee makers, computer housing.
- ◆ Electronics – Housings, covers, displays, bezels, boxes, storage, memory, optics, trays, keyboards, mice, conductors, insulators, diodes, capacitors, cords, wiring.
- ◆ House wares – Cutlery, handles, boards, boxes, glasses, dishes, utensils, bins, aquariums, terrariums, bowls, pitchers.
- ◆ Construction – Coatings, paints, films, tanks, plumbing fixtures, sinks, glazing, cabinets, doors, flooring, bathrooms, fixtures, showers, roofing gutters, siding, decking, lighting, skylights, atriums, booths, blocks, structural supports, facades, cladding, signs, trim, shelving, racking, piping, pipe, tubes, junction boxes, connectors, insulators, insulation, foams.
- ◆ Safety – Glasses, shields, apparel, padding, helmets, barricades, lenses, lights, bumpers, delineators, braces, signs, reflectors, cones, helmets, barrels.
- ◆ Agricultural and farming – Housings, trays, films, greenhouse, pots, seed trays, tools, blades, silos, grain storage, storage vessels, tanks, dairy tanks, troughs, cow feeders, pens, dividers, enclosures.
- ◆ Apparel - Buttons, bangles, beads, bands, belting, boots, jewelry, rings, shoes, sandals, straps, belts, fibers, flocking, insulation, rod, sheet, tube, bullet proof vests, face shield, visors, eyewear, goggles, orthopedics, prosthetics, diapers, hair clips, hats, fake nails, dental, helmets, pads.
- ◆ Toys - Balls, guns, dolls, cars, blocks, games, pieces, dice, cubes, flying disks, rattles, trains, trucks, planes, models, riding toys, bicycles, baby seats, car seats, basketball backboards, action toys, swings, seats, sliding boards, playgrounds, toy housing, toy animals, pet toys, figurines, toy boats, floats, pools, tanks, padding, displays, doll houses, boards.
- ◆ Lawn and garden – Rakes, shovels, chairs, trowels, tillers, blades, lawn mowers, housings, weed whackers, hoses, sprinklers, tables, furniture, decking, enclosures, light holders, picnic tables, umbrellas.
- ◆ Military – Shielding, firearms, housings, vessels, helmets, boots, apparel, armor, displays, shelters, canopies, aircraft, bullets, skins, sonar coverings, cables.
- ◆ Medical – Tubing, catheters, valves, prosthetics, needles, syringes, pans, packaging, piping, pumps, displays, implants, casts, machines.
- ◆ Furniture – Tables, chairs, counters, stands, planters, lanterns, stools, desks, lamps, lighting, chandeliers, couches, ladders, stairs, vases.
- ◆ Marine – Boats, canoes, kayaks, hulls, skins, seats, supports, steering wheels, dash boards, windows, buoys, bumpers, rope, netting, patches, hatches, oars, dinghies, motor housings, displays, housing, sails, hooks, pulleys, galleys, heads, paneling, interior, flooring, wall covering, mast, cleats.

- ◆ Sporting goods – Fishing lures, backboards, billiard balls, pool tables, ping pong tables, rackets, paddles, balls, strings, pools, bows, guns, tents, poles, chairs, cleats, skis, hockey pucks, ski goggles, poles, skates, boats, rollers, wheels, roller blades, scooters, pads, helmets, posts, rims, netting, bowling balls and pins, shafts, golf clubs, golf ball cover, tees, golf carts, golf bags, fins, goggles, snorkels, hockey sticks, fishing poles, horseshoes, vaulting poles.
- ◆ Packaging – Bottles, trays, films, boxes, foams, cans, jars, dispensers, toilet paper and paper towel dispensers, lids.
- ◆ Tools – Handles, flashlights, lighting, optics, mallets, power tools, housings, tables, hoses.
- ◆ Utilities – Solar panels, windmill blades, wave baffles, turbine blades, hydraulic blades, impellor parts, batteries, housings, light piping, lenses, solar lenses, solar laser, giant lenses.
- ◆ Communications – Telephones, fiber optics, digital media, credit cards, smart cards, cd cards, phone cards, business cards, pens, speakers, faxes, mail boxes, wires, cell phones, cables, wire, relays, piping, conduits, satellite dishes.
- ◆ Textiles – Woven and unwoven fiber, reflective, illuminated, luminous, spun, and drawn.
- ◆ Industrial – Hoses, tubes, seals, belts, gears, wheels, casters, rollers, tires, hoses, tubes, adhesives both hot melts and solvent based.



EXHIBITS A, B, C



**DIAMOND POLYMERS, INC.**

**FACSIMILE TRANSMITTAL SHEET**

TO:	FROM:
Jim Rauh	Ellen A. Phillips
COMPANY:	DATE:
Engineered Plastics	DECEMBER 6, 2002
FAX NUMBER:	TOTAL NO. OF PAGES INCLUDING COVER:
330/376-5811	6
PHONE NUMBER:	CC:
330/376-7700	S. Blazey, A. Woll
RE:	
TPE - UB50 Analysis	

☐ URGENT ☒ FOR REVIEW ☐ PLEASE COMMENT ☐ PLEASE REPLY ☐ PLEASE RECYCLE

Tg = Glass Transition Temperature  
Tm = Melting Temperature

	Literature Values	Actual
ABS - Tg	105 - 125°C	99.0 (Depends on impact)
Polyurethane - Tg	120 - 160°C	110.8°C (Depends on hardness)
PBT - Tm	220 - 270°C	221.6°C
Fatty Acid Additive - Tm	---	35.7, 104.8, 132.3°C

The materials will interact with each other and raise or lower both Tg and Tm. The DSM material analysis is also included. If you have any questions, please call to discuss.

Regards,  
Ellen A. Phillips  
Research & Development Manager

1355 EXTER ROAD, AKRON, OHIO 44306

PHONE: 330.773.2700

FAX: 330.773.2799

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## EXHIBIT A

TPE UB50 LOT 11407: L-1971b1  
 Unsubtracted Heat Flow Endo Down (mW): Step: 6  
 TPE UB50 LOT 11405: L-1971a1  
 Unsubtracted Heat Flow Endo Down (mW): Step: 6

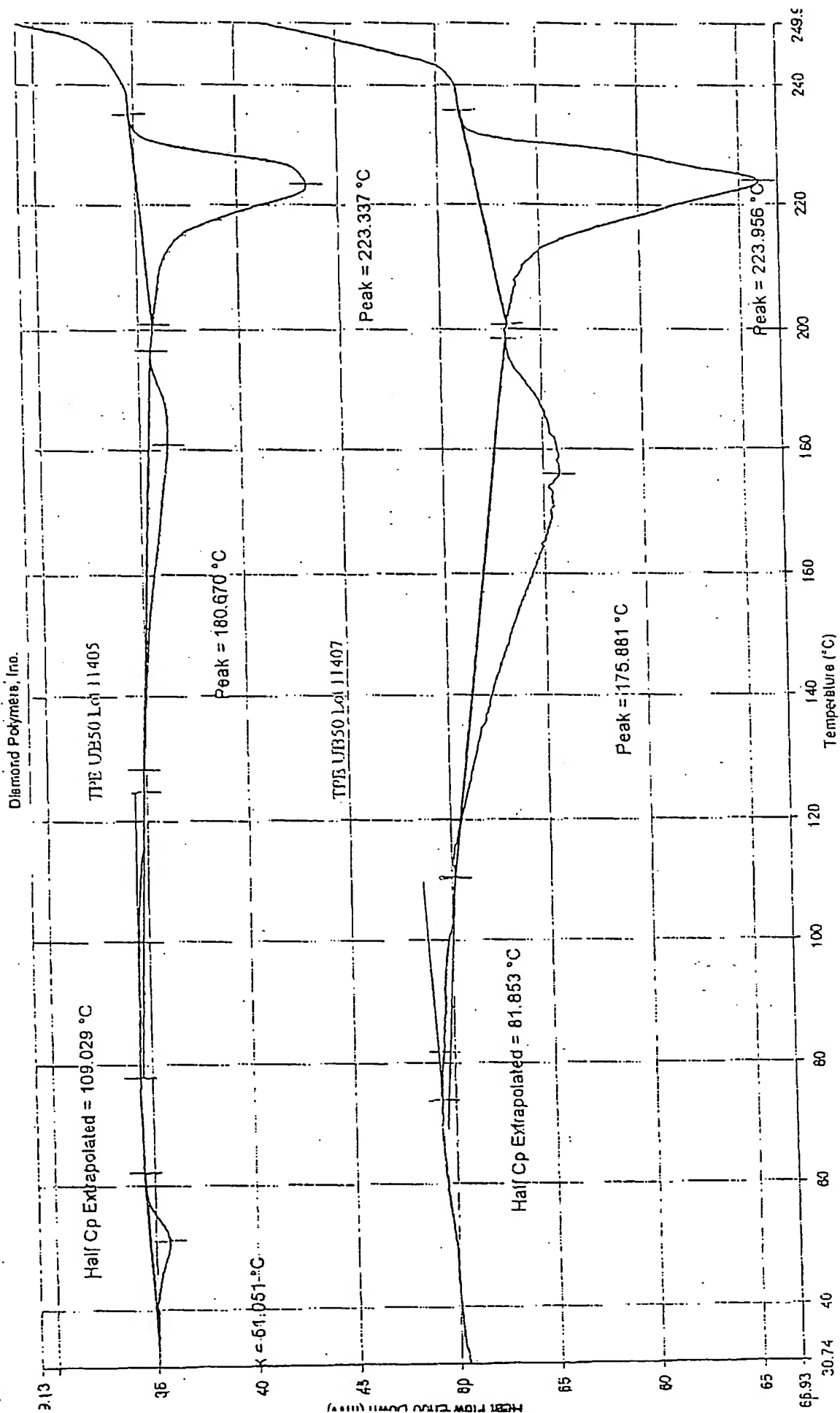
Filename: C:\Program Files\Pyris\Data\...L-1971b1.dcd

Operator ID: EAP

Sample ID: TPE UB50 LOT 11407

Sample Weight: 22.300 mg

Comment: ENGINEERED PLASTICS



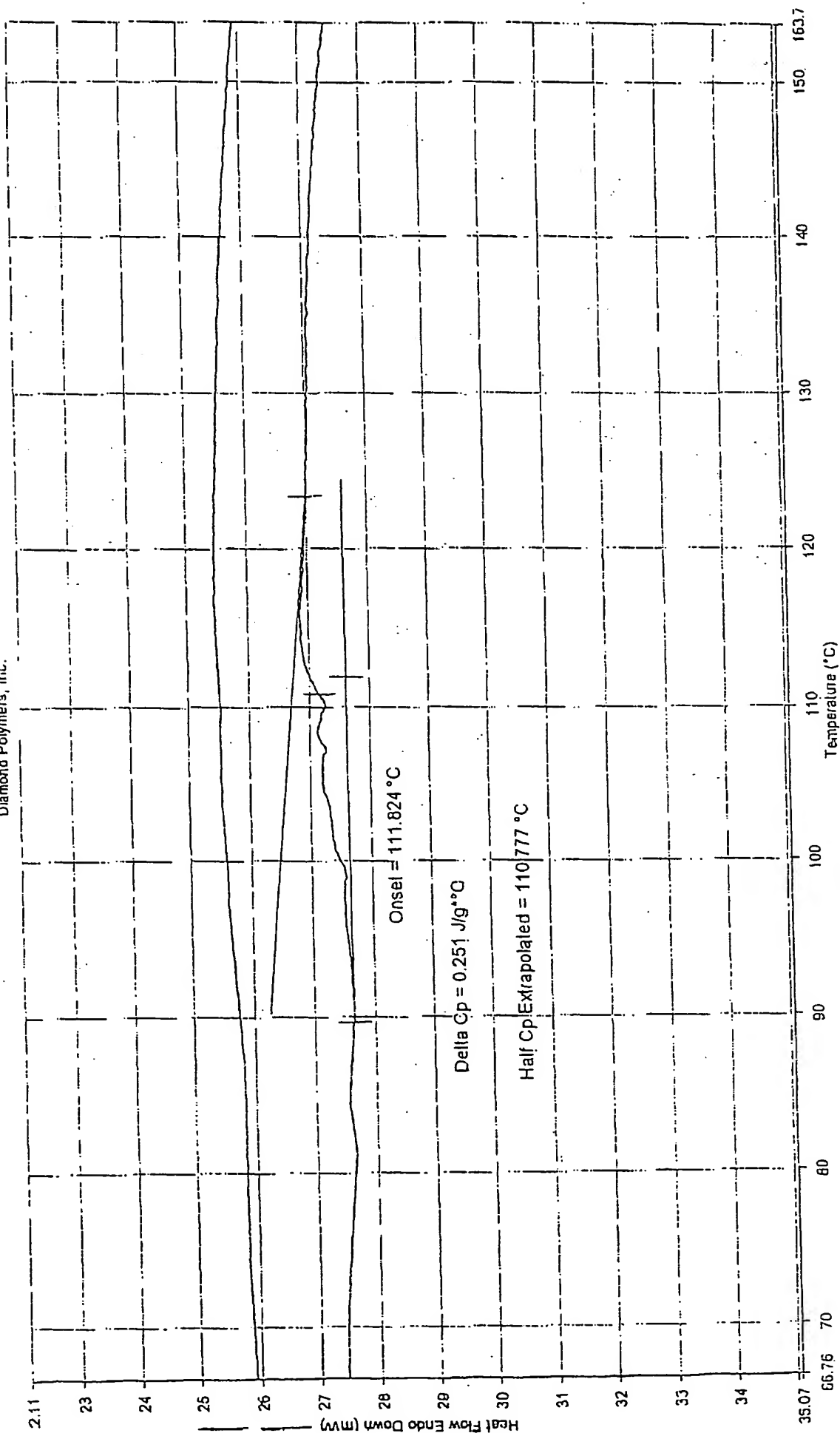
12/6/02 1:16:25 PM

- 1) Heat from 25.00 °C to 280.00 °C at 20.00 °C/min
- 2) Hold for 10.0 min at 280.00 °C
- 3) Cool from 280.00 °C to 25.00 °C at 20.00 °C/min
- 4) Hold for 10.0 min at 25.00 °C
- 6) Heat from 25.00 °C to 280.00 °C at 20.00 °C/min

URETHANE RAW MATERIAL: L-1971E.dcd  
 Unsubtracted Heat Flow Endo Down (mW) : Step: 6  
 URETHANE RAW MATERIAL: L-1971E.dcd  
 Unsubtracted Heat Flow Endo Down (mW) : Step: 1

Filename: C:\PEP\mjs\Data\Baseline...L-1971E.dcd.dcd  
 Operator ID: BAP  
 Sample ID: URETHANE RAW MATERIAL  
 Sample Weight: 10.700 mg  
 Comment: ENGINEERED PRODUCTS

Diamond Polymers, Inc.



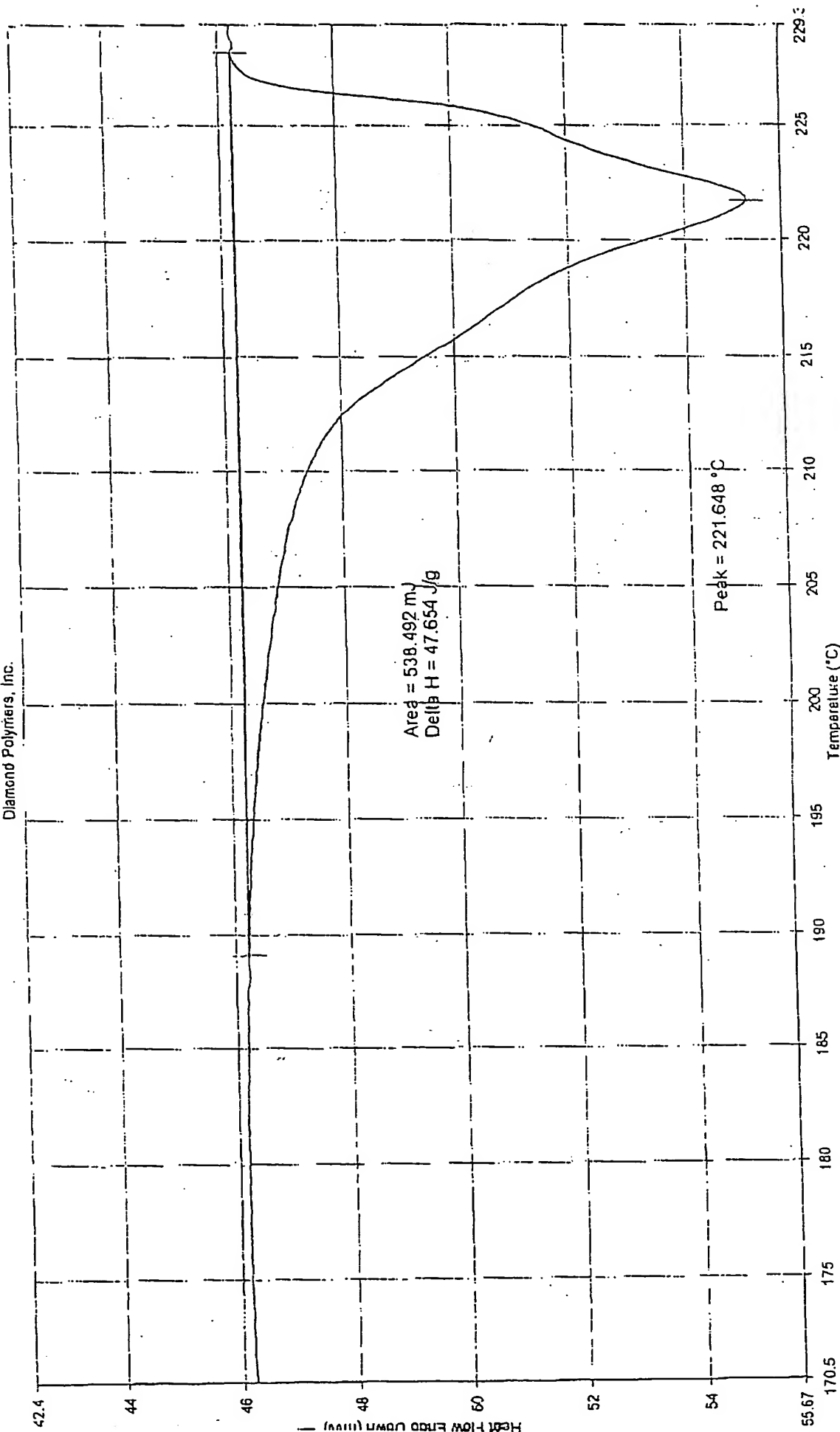
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- 1) Heat from 25.00°C to 200.00°C at 20.00°C/min
- 2) Hold for 10.0 min at 200.00°C
- 3) Cool from 200.00°C to 25.00°C at 20.00°C/min
- 4) Hold for 10.0 min at 25.00°C
- 5) Heat from 25.00°C to 200.00°C at 20.00°C/min

PBT RAW MATERIAL: L-1971D.dcd  
Unsubtracted Heat Flow Endo Down (mW) : Step: 4

Filename: C:\PEP\pysData\LAB PRO...L-1971D.dcd.dcd  
perator ID: EAP  
ample ID: PBT RAW MATERIAL  
ample Weight: 11.300 mg  
omment: ENGINEERED PRODUCTS

Diamond Polymers, Inc.



11/26/02 1:14:37 PM

- 1) Heat from 100.00°C to 250.00°C at 10.00°C/min
- 2) Hold for 10.0 min at 250.00°C
- 3) Cool from 250.00°C to 100.00°C at 10.00°C/min
- 4) Heat from 100.00°C to 250.00°C at 10.00°C/min
- 5) Hold for 10.0 min at 250.00°C
- 6) Cool from 250.00°C to 25.00°C at 10.00°C/min

## EXHIBIT D



Friday, January 10, 2003

## VALOX® 315

Units: English

GE Plastics - Polybutylene Terephthalate

## Actions

- - ISO Data Sheet
- - CAMPUS® Data Sheet
- ☒ - Sourcing Information

## Product Description

Unreinforced, extrusion. High viscosity. FDA and USP Class VI compliant. Melt viscosity between 7500 and 9500 poise.

## Product Characteristics

Material Status	• Commercial: Active
Availability	• North America
Test Standards Available	• ASTM
Features	• Viscosity, High
Agency Ratings	• USP Class VI
	• FDA Unspecified Rating <sup>1</sup>
Forms	• Pellets
Processing Method	• Injection Molding
	• Extrusion
Multi-Point Data	• Viscosity vs. Shear Rate (ASTM D3835)
	• Tensile Creep (ASTM D2990)
	• Elastic Modulus vs Temperature (ASTM D4065)
	• Tensile Stress vs. Strain (ASTM D638)

Properties <sup>2</sup>

Physical	Nominal Values (English)	Test Method
Density - Specific Gravity	1.31 sp gr 23/23°C	ASTM D792
Mold Shrink, Linear-Flow (0.135 in) (0.0600 in)	0.015 to 0.023 in/in 0.0090 to 0.016 in/in	ASTM D955
Mold Shrink, Linear-Trans (0.135 in) (0.0600 in)	0.016 to 0.024 in/in 0.010 to 0.017 in/in	ASTM D955
Water Absorption @ 24 hrs (73 °F)	0.080 %	ASTM D570
Mechanical	Nominal Values (English)	Test Method
Tensile Strength @ Yield <sup>3</sup>	7500 psi	ASTM D638
Tensile Elongation @ Brk <sup>3</sup>	300 %	ASTM D638
Flexural Modulus (2.00 in Span) <sup>4</sup>	340000 psi	ASTM D790
Flexural Strength @ Yield (2.00 in Span) <sup>4</sup>	12000 psi	ASTM D790
Impact	Nominal Values (English)	Test Method
Notched Izod Impact (73 °F)	1.00 ft-lb/in	ASTM D256
Unnotched Izod Impact (73 °F)	30.0 ft-lb/in	ASTM D256
Hardness	Nominal Values (English)	Test Method
Rockwell Hardness (R-Scale)	117	ASTM D785
Thermal	Nominal Values (English)	Test Method
DTUL @264psi - Unannealed (0.250 in)	130 °F	ASTM D648
DTUL @66psi - Unannealed (0.250 in)	310 °F	ASTM D648
CLTE, Flow (140 to 280°F (60 to 138°C))	7.7E-005 in/in/°F	ASTM D696

## EXHIBIT D-2

Rockwell Hardness (R-Scale)	117	ASTM D785
<b>Thermal</b>	<b>Nominal Values (English)</b>	<b>Test Method</b>
DTUL @264psi - Unannealed (0.250 in)	130 °F	ASTM D648
DTUL @66psi - Unannealed (0.250 in)	310 °F	ASTM D648
CLTE, Flow		ASTM D696
(140 to 280°F (60 to 138°C))	7.7E-005 in/in/°F	
(-40 to 100°F (-40 to 38°C))	4.5E-005 in/in/°F	
<b>Electrical</b>	<b>Nominal Values (English)</b>	<b>Test Method</b>
Volume Resistivity	4.0E+016 ohm-cm	ASTM D257
Dielectric Strength		ASTM D149
(In Oil, 0.0620 in)	590 V/mil	
(In Air, 0.125 in)	400 V/mil	
Dielectric Constant		ASTM D150
(1000000 Hz)	3.100	
(100 Hz)	3.300	
Dissipation Factor		ASTM D150
(1000000 Hz)	0.020	
(100 Hz)	0.0020	
<b>Additional Properties</b>		
Melt Viscosity, GE: 7500.0000 poise		
Modified Gardner, 73F, ASTM D 3029: 30.0000 ft-lbs		
Specific Volume, ASTM D 792: 21.3000 in <sup>3</sup> /lb		
Volume Resistivity, ASTM D 257: >4.0E16 ohm-cm		
<b>Injection Molding Parameters</b>	<b>Nominal Values (English)</b>	<b>Test Method</b>
Drying Temperature	250 °F	
Drying Time	3.0 to 4.0 hr	
Drying Time, Maximum	12 hr	
Suggested Max Moisture	0.020 %	
Suggested Shot Size	40 to 80 %	
Rear Temperature	450 to 480 °F	
Middle Temperature	460 to 490 °F	
Front Temperature	470 to 500 °F	
Nozzle Temperature	460 to 490 °F	
Processing (Melt) Temp	470 to 500 °F	
Mold Temperature	120 to 170 °F	
Back Pressure	50.0 to 100 psi	
Screw Speed	50 to 100 rpm	
Clamp Tonnage	3.0 to 5.0 tons/in <sup>2</sup>	
Vent Depth	0.00050 to 0.0010 in	
<b>Extrusion Molding Parameters</b>	<b>Nominal Values (English)</b>	<b>Test Method</b>
Drying Temperature	250 °F	
Drying Time	4.0 hr	
Cylinder Zone 1 Temp.	470 to 500 °F	
Cylinder Zone 2 Temp.	470 to 500 °F	
Cylinder Zone 3 Temp.	470 to 500 °F	
Cylinder Zone 4 Temp.	470 to 500 °F	
Cylinder Zone 5 Temp.	470 to 500 °F	
Melt Temperature	470 to 500 °F	

**Extrusion Notes**

SCREW DESIGN: 3.0 -3.8:1 compression ratio or  
 barrier Maddox design  
 24:1 L/D minimum

EXHIBIT E



Friday, January 10, 2003

# **Texin® 245**

Bayer Corporation, Plastics Division - Thermoplastic Polyurethane Elastomer  
(Polyester)

Units: English

## **Actions**

- - ISO Data Sheet
- CAMPUS® Data Sheet
- Sourcing Information

## **Product Description**

The Taber Abrasion was tested in accordance with ASTM D3489.  
The Glass Transition Temperature was tested using Dynamic Mechanical Analysis.

## **Product Characteristics**

Material Status	• Commercial: Active
Availability	• North America
Test Standards Available	• ASTM • ISO 10350
Recycled Content	• No
Features	• Moldability, Good • Abrasion Resistance, Good • Resilient • Chemical Resistance, Good • Strength, High • Impact Resistance, Good • Toughness, Good • Flexibility, Good • Food Contact Acceptable
Uses	• Gears • Sporting Goods • Cams • Hydraulic Applications • Parts, Machine/Mechanical
Agency Ratings	• FDA 21 CFR 177.1680 • FDA 21 CFR 177.2600
Appearance	• Colors Available • Black
Forms	• Pellets
Processing Method	• Injection Molding

## **Properties <sup>3</sup>**

Physical	Nominal Values (English)	Test Method
Density - Specific Gravity	1.21 sp gr 23/23°C	ASTM D792
Mold Shrink, Linear-Flow (0.125 in)	0.0070 to 0.010 in/in	ASTM D955
Mechanical	Nominal Values (English)	Test Method
Flexural Modulus (73 °F)	10000 psi	ASTM D790
Taber Abrasion Resistance (H-18 Wheel, 1000 gm, 1000 Cycles)	70.0 mg	ASTM D1044
Elastomers	Nominal Values (English)	Test Method
Tensile Stress @ 50%	1100 psi	ASTM D412
Tensile Stress @ 100%	1300 psi	ASTM D412
Tensile Stress @ 300%	2800 psi	ASTM D412
Tensile Str @ Break Elast	6000 psi	ASTM D412
Elongation @ Break Elast	500 %	ASTM D412

Tear Strength (Die C)	700 pli	ASTM D624
Compression Set (73 °F, 22 hr)	18 %	ASTM D395
<b>Impact</b>	<b>Nominal Values (English)</b>	<b>Test Method</b>
Notched Izod Impact (-22 °F, 0.125 in) (73 °F, 0.125 in)	3.30 ft-lb/in No Break ft-lb/in	ASTM D256
<b>Hardness</b>	<b>Nominal Values (English)</b>	<b>Test Method</b>
Durometer Hardness (D Scale)	45	ASTM D2240
<b>Thermal</b>	<b>Nominal Values (English)</b>	<b>Test Method</b>
Brittle Temperature	-90.0 °F	ASTM D746
Glass Transition Temp	-51.0 °F	ASTM E1356
Vicat Softening Point (Rate A)	298 °F	ASTM D1525
<b>Ignition Characteristics</b>	<b>Nominal Values (English)</b>	<b>Test Method</b>
Flame Rating - UL (0.0590 in, NC) (0.118 in, NC)	HB HB	UL 94
<b>UL 746</b>	<b>Nominal Values (English)</b>	<b>Test Method</b>
Rel Temp Indx Mech w/olmp (0.0590 in)	122 °F	UL 746
Rel Temp Indx Mech w/lmp (0.0590 in)	122 °F	UL 746
Rel Temp Indx Elect (0.0590 in)	122 °F	UL 746

**Additional Properties**

Bayshore Resilience, ASTM D2632: 45%  
 Compression Set, ASTM D395-B, As Molded, 22 hrs @ 158°F, Postcured, 16 hrs @ 230°F: 43%  
 Compression Set, ASTM D395-B, As Molded, 22 hrs @ 158°F, Postcured, 16 hrs @ 230°F: 35%  
 Compression Set, ASTM D395-B, As Molded, 22 hrs @ 73°F, Postcured, 16 hrs @ 230°F: 18%  
 Flexural Modulus, ASTM D790, 158°F: 4500 psi  
 Compressive Load, ASTM D575, 2% Deflection: 100 psi  
 Compressive Load, ASTM D575, 5% Deflection: 300 psi  
 Compressive Load, ASTM D575, 10% Deflection: 560 psi  
 Compressive Load, ASTM D575, 15% Deflection: 800 psi  
 Compressive Load, ASTM D575, 20% Deflection: 1000 psi  
 Compressive Load, ASTM D575, 25% Deflection: 1300 psi  
 Compressive Load, ASTM D575, 50% Deflection: 3400 psi

**Processing Information**

<b>Injection Molding Parameters</b>	<b>Nominal Values (English)</b>	<b>Test Method</b>
Drying Temperature	210 to 230 °F	
Drying Time	2.0 hr	
Suggested Max Moisture	0.030 %	
Suggested Max Regrind	20 %	
Rear Temperature	380 to 410 °F	
Middle Temperature	380 to 420 °F	
Front Temperature	390 to 430 °F	
Nozzle Temperature	400 to 440 °F	
Processing (Melt) Temp	410 to 430 °F	
Mold Temperature	60.0 to 100 °F	
Injection Pressure	6000 to 15000 psi	
Injection Rate	Slow-Moderate	
Back Pressure	200 psi	
Screw Speed	40 to 80 rpm	
Clamp Tonnage	3.0 to 5.0 tons/in <sup>2</sup>	
Cushion	0.125 in	
Screw L/D Ratio	20.0:1.0	
Screw Compression Ratio	2.5:1.0 to 3.0:1.0	

**Notes**



**ESTANE® 58137 TPU****PRODUCT DATA SHEET**

**DESCRIPTION:** 67D Polyester-Type Thermoplastic Polyurethane (TPU) Compound  
**SPECIAL FEATURES:** Fast Cycling, Broad Temperature Performance, Durability, Paintability  
**TYPICAL PROCESS:** Injection Molding  
**PRE-DRYING:** 2 hours at 104°C (220°F) in Dehumidifying Hopper Dryer

Typical Properties	Test Method	Typical Values*	
		SI Units	English Units
<b>PHYSICAL</b>			
Shore Hardness	ASTM D-2240	67D	67D
Specific Gravity	ASTM D-792	1.24	1.24
<b>MECHANICAL</b>			
Tensile Strength	ASTM D-412	37.2 MPa	5,400 psi
Tensile Modulus	ASTM D-412		
@ 100% Elongation		20.7 MPa	3,000 psi
@ 300% Elongation		29.0 MPa	4,200 psi
Ultimate Elongation	ASTM D-412	430%	430%
Flexural Modulus @ 23°C	ASTM D-790	413.8 MPa	60,000 psi
Tear Strength	ASTM D-624, Die C	192.5 kN/m	1,100 lb/in
Taber Abrasion	ASTM D-3389 B		
CS-17 wheel, 1kg load, 1,000 cycles		19.0 mg	19.0 mg
<b>THERMAL</b>			
Glass Transition Temperature	DSC**	- 22°C	- 8°F
Vicat Softening Point	ASTM D-1525	154°C	309°F

\*These are typical values and should not be used for establishing specifications. Contact your representative for availability and commercialization status.

\*\*Differential Scanning Calorimeter, 10°C/min. temperature program

**noveon**  
 The Specialty Chemicals Innovator™

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**BEST AVAILABLE COPY**

## EXHIBIT G



Thursday, March 20, 2003

Titan(TM) MN001

PCT

Eastman Chemical Company - Polycyclohexylenedimethylene Terephthalate

Units: English

## Actions

- - ISO Data Sheet
- - CAMPUS® Data Sheet
- ☒ - Sourcing Information

## Product Characteristics

Material Status	• Commercial: Active
Availability	• North America
	• Europe
Test Standards Available	• ASTM
Recycled Content	• No
Uses	• Medical Applications
Forms	• Pellets
Processing Method	• Injection Molding

## Properties

Physical	Nominal Values (English)	Test Method
Density - Specific Gravity	1.38 sp gr 23/23°C	ASTM D792
Water Absorption @ 24 hrs (73 °F)	0.010 %	ASTM D570

Mechanical	Nominal Values (English)	Test Method
Tensile Modulus (73 °F)	1450000 psi	ASTM D638
Tensile Strength @ Break (73 °F)	21000 psi	ASTM D638
Tensile Elongation @ Brk (73 °F)	2.7 %	ASTM D638
Flexural Modulus (73 °F)	1230000 psi	ASTM D790
Flexural Strength (73 °F)	23200 psi	ASTM D790

Impact	Nominal Values (English)	Test Method
Notched Izod Impact (-22 °F)	7.49 ft-lb/in	ASTM D256
(73 °F)	8.43 ft-lb/in	
Unnotched Izod Impact (-22 °F)	11.2 ft-lb/in	ASTM D256
(73 °F)	17.8 ft-lb/in	

Hardness	Nominal Values (English)	Test Method
Rockwell Hardness (R-Scale)	112	ASTM D785

Thermal	Nominal Values (English)	Test Method
DTUL @264psi - Unannealed	527 °F	ASTM D648
DTUL @66psi - Unannealed	590 °F	ASTM D648
Melting Point	617 °F	

## Processing Information

Injection Molding Parameters	Nominal Values (English)	Test Method
Drying Temperature	248 to 302 °F	
Drying Time	4.0 to 6.0 hr	
Processing (Melt) Temp	644 °F	
Mold Temperature	104 to 203 °F	

## Notes

<sup>1</sup> Typical properties; not to be construed as specifications.

EXHIBIT H

PC

Prepared by  
**IDES**

Thursday, March 20, 2003

**Makrolon® 2205**

Bayer Corporation, Plastics Division - Polycarbonate

Units: English

**Actions**

- - ISO Data Sheet

I - CAMPUS® Data Sheet

S - Sourcing Information

**Product Characteristics**

Material Status	• Commercial: Active
Availability	• North America
Test Standards	• ASTM
Available	• ISO 10350
Recycled Content	• No
Features	• Dimensional Stability, Good • Impact Resistance, High • Electrical Properties, Good • Thermal Stability, Good
Uses	• Automotive Applications • Electrical/Electronic Applications • Construction Applications • Medical Applications • Business Equipment • Optical Applications • Tools, Power/Others • Packaging • Containers, Food • Bottles • Sporting Goods • Optical Data Storage • Appliances
Appearance	• Transparent • Natural Color
Forms	• Pellets
Processing Method	• Injection Molding
Multi-Point Data	• Viscosity vs. Shear Rate (ISO 11403-2) • Secant Modulus vs. Strain (ISO 11403-1) • Shear Modulus vs. Temperature (ISO 11403-2) • Isochronous Stress vs. Strain (ISO 11403-1) • Isothermal Stress vs. Strain (ISO 11403-1) • Creep Modulus vs. Time (ISO 11403-1)

**Properties**

Physical	Nominal Values (English)	Test Method
Density - Specific Gravity	1.20 sp gr 23/23°C	ASTM D792
Melt Flow Rate (300°C/1.2 kg - O)	33.0 g/10 min	ASTM D1238
Mold Shrink, Linear-Flow	0.0050 to 0.0070 in/in	ASTM D955
Water Absorption @ 24 hrs	0.15 %	ASTM D570
Water Absorption @ Sat. (73 °F)	0.35 %	ASTM D570

Mechanical	Nominal Values (English)	Test Method
Tensile Modulus	330000 psi	ASTM D638
Tensile Strength @ Yield	9100 psi	ASTM D638
Tensile Strength @ Break	8700 psi	ASTM D638
Tensile Elongation @ Yld	6.0 %	ASTM D638
Tensile Elongation @ Brk	110 %	ASTM D638
Flexural Modulus	340000 psi	ASTM D790
Flexural Strength	12000 psi	ASTM D790

Impact	Nominal Values (English)	Test Method
Notched Izod Impact (73 °F, 0.125 in)	12.00 ft-lb/in	ASTM D256

Hardness	Nominal Values (English)	Test Method
Rockwell Hardness (M-Scale)		ASTM D785

## EXHIBIT H-2

(R-Scale)		118
Thermal		
Nominal Values (English)		Test Method
DTUL @264psi - Unannealed	252 °F	ASTM D648
DTUL @66psi - Unannealed	273 °F	ASTM D648
Vicat Softening Point (Rate A)	289 °F	ASTM D1525
CLTE, Flow	3.9E-005 in/in/°F	ASTM D696
Thermal Conductivity	1.4 BTU-in/hr/ft²/°F	ASTM C177
Specific Heat	0.280 Btu/lb/°F	ASTM C351
Electrical		
Nominal Values (English)		Test Method
Surface Resistivity	1.0E+015 ohms	ASTM D257
Volume Resistivity	1.0E+016 ohm-cm	ASTM D257
Dielectric Strength (in Oil, 0.0620 in)	760 V/mil	ASTM D149
Dielectric Constant		ASTM D150
(60 Hz)	3.000	
(1000000 Hz)	2.900	
Dissipation Factor		ASTM D150
(60 Hz)	0.00080	
(1000000 Hz)	0.010	
Ignition Characteristics		
Nominal Values (English)		Test Method
Flame Rating - UL		UL 94
(0.0590 in)	V-2	
(0.118 in)	HB	
(0.250 in)	V-2	
Limiting Oxygen Index	26 %	ASTM D2863
UL 746		
Nominal Values (English)		Test Method
Rel Temp Indx Mech w/olmp (0.0590 in)	176 °F	UL 746
Rel Temp Indx Mech w/lmp (0.0590 in)	176 °F	UL 746
Rel Temp Indx Elect (0.0590 in)	176 °F	UL 746
Optical		
Nominal Values (English)		Test Method
Refractive Index	1.584	ASTM D542
Transmittance	88.0 %	ASTM D1003
Haze	1.0 %	ASTM D1003

## Additional Properties

The value listed as Specific Heat, ASTM C351, was tested in accordance with ASTM D2766.

Flexural Stress, ASTM D790, 5% Strain: 12,000 psi

Processing Information		
Injection Molding Parameters		Test Method
Nominal Values (English)		
Drying Temperature	250 °F	
Drying Time	4.0 hr	
Suggested Max Moisture	0.020 %	
Suggested Max Re grind	20 %	
Rear Temperature	445 to 495 °F	
Middle Temperature	510 to 550 °F	
Front Temperature	530 to 570 °F	
Nozzle Temperature	510 to 530 °F	
Processing (Melt) Temp	535 to 565 °F	
Mold Temperature	150 to 220 °F	
Injection Pressure	10000 to 15000 psi	
Back Pressure	50.0 to 100 psi	
Screw Speed	75 to 100 rpm	
Clamp Tonnage	3.0 to 5.0 tons/in²	
Screw L/D Ratio	20.0:1.0	
Screw Compression Ratio	2.0:1.0 to 3.0:1.0	

EXHIBIT I

Powered by  
**IDES**

Thursday, March 20, 2003

**Eastar® 5011**

PETG

Eastman Chemical Company - Polyethylene Terephthalate Glycol Comonomer

Units: English

**Actions**

- - ISO Data Sheet
- - CAMPUS® Data Sheet
- ☒ - Sourcing Information

**Product Characteristics**

Material Status	• Commercial: Active
Availability	• North America
	• Europe
Test Standards Available	• ASTM
Recycled Content	• No
Features	• Toughness, Good
	• Amorphous
Uses	• Cosmetics • Sporting Goods
	• Packaging, Cosmetic • Writing Instruments
	• Toys • Stationary Supplies
Forms	• Pellets
Processing Method	• Extrusion
	• Injection Molding

**Properties**

Physical	Nominal Values (English)	Test Method
Density - Specific Gravity	1.28 sp gr 23/23°C	ASTM D792
Mold Shrink, Linear-Flow (0.125 in)	0.0020 in/in	ASTM D955
Water Absorption @ 24 hrs (73 °F)	0.13 %	ASTM D570

Mechanical	Nominal Values (English)	Test Method
Tensile Strength @ Break (73 °F)	3600 psi	ASTM D638
Tensile Elongation @ Brk (73 °F)	15 %	ASTM D638
Flexural Modulus (73 °F)	320000 psi	ASTM D790
Flexural Strength (73 °F)	10600 psi	ASTM D790
Coef. of Friction	1.0	ASTM D1894

Impact	Nominal Values (English)	Test Method
Notched Izod Impact		ASTM D256
(-40 °F)	0.50 ft-lb/in	
(73 °F)	1.30 ft-lb/in	
Unnotched Izod Impact		ASTM D256
(-40 °F)	50.0 ft-lb/in	
(73 °F)	No Break ft-lb/in	

Hardness	Nominal Values (English)	Test Method
Rockwell Hardness (R-Scale)	106	ASTM D785

Thermal	Nominal Values (English)	Test Method
DTUL @264psi - Unannealed	143 °F	ASTM D648
DTUL @66psi - Unannealed	152 °F	ASTM D648

**Additional Properties**

The values listed as Unnotched Izod Impact, ASTM D256, were tested in accordance with ASTM D4812.  
Mold Shrinkage, ASTM D955, Parallel, 0.0625 in: 0.005 in/in

**Processing Information**

Injection Molding Parameters	Nominal Values (English)	Test Method
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## EXHIBIT J

Powered by  
**IDES**

Thursday, March 20, 2003

**Easter® 7352****PET**

Eastman Chemical Company - Polyethylene Terephthalate

Units: **English****Actions**

- - ISO Data Sheet
- - CAMPUS® Data Sheet
- ☒ - Sourcing Information

**Product Characteristics**

Material Status	• Commercial: Active
Availability	• North America
Test Standards Available	• ASTM
Recycled Content	• No
Forms	• Pellets
Processing Method	• Injection Molding

**Properties**

Physical	Nominal Values (English)	Test Method
Density - Specific Gravity	1.41 sp gr 23/23°C	ASTM D792
Apparent Density	0.819 sp gr 23/23°C	ASTM D1895
Mechanical	Nominal Values (English)	Test Method
Tensile Strength @ Yield	8290 psi	ASTM D638
Tensile Strength @ Break	3520 psi	ASTM D638
Tensile Elongation @ Yld	4.0 %	ASTM D638
Tensile Elongation @ Brk	68 %	ASTM D638
Flexural Modulus	363000 psi	ASTM D790
Flexural Strength @ Yield	11700 psi	ASTM D790
Impact	Nominal Values (English)	Test Method
Notched Izod Impact (-40 °F)	0.80 ft-lb/in	ASTM D256
(73 °F)	2.00 ft-lb/in	
Unnotched Izod Impact (73 °F)	No Break ft-lb/in	ASTM D256
Hardness	Nominal Values (English)	Test Method
Rockwell Hardness (R-Scale)	108	ASTM D785
Thermal	Nominal Values (English)	Test Method
DTUL @264psi - Unannealed	142 °F	ASTM D648
Melting Point	482 °F	
Thermal Conductivity	1.7 BTU-in/hr/ft²/°F	ASTM C177
Specific Heat	0.260 Btu/lb/°F	ASTM C351

**Additional Properties**

Melt Density @ 285°C, g/cm³, ASTM D 1238: 1.2

**Processing Information**

Injection Molding Parameters	Nominal Values (English)	Test Method
Drying Temperature	300 °F	
Drying Time	4.0 hr	
Processing (Melt) Temp	550 °F	
Mold Temperature	70.0 °F	

**Notes**

- 1 Typical properties; not to be construed as specifications.

**EASTMAN**

## EXHIBIT K

# **EASTALLOY Polymer DA003-8999K, Clear** **Product Data Sheet**

PCTG

Property <sup>a</sup>	Test <sup>b</sup> Method	Typical Value, Units <sup>c</sup>
<b>General Properties (ASTM Method)</b>		
Specific Gravity	D 792	1.20
Water Absorption, 24-h immersion	D 570	0.13%
Mold Shrinkage Parallel to Flow, 3.2-mm (0.125-in.) thickness	D 955	0.005-0.007 mm/mm (0.005-0.007 in./in.)
<b>Mechanical Properties (ASTM Method)</b>		
Tensile Stress @ Yield	D 638	56 MPa (8100 psi)
Tensile Stress @ Break	D 638	60 MPa (8700 psi)
Elongation @ Yield	D 638	6%
Elongation @ Break	D 638	150%
Flexural Modulus	D 790	2140 MPa (3.1 x 10 <sup>5</sup> psi)
Flexural Yield Strength	D 790	86 MPa (12500 psi)
Rockwell Hardness, R Scale	D 785	117
Izod Impact Strength, Notched		
@ 23°C (73°F)	D 256	NB
@ -40°C (-40°F)	D 256	75 J/m (1.4 ft·lbf/in.)
Impact Strength, Unnotched		
@ 23°C (73°F)	D 4812	NB
@ -40°C (-40°F)	D 4812	NB
Impact Resistance (Puncture), Energy @ Max. Load		
@ 23°C (73°F)	D 3763	51 J (38 ft·lbf)
@ -40°C (-40°F)	D 3763	46 J (34 ft·lbf)
<b>Thermal Properties (ASTM Method)</b>		
Deflection Temperature		
@ 0.455 MPa (66 psi)	D 648	103°C (218°F)
@ 1.82 MPa (264 psi)	D 648	90°C (194°F)
Vicat Softening Temperature @ 1 kg load	D 1525	118°C (244°F)
Specific Heat		
@ 60°C (140°F)	DSC	1.38 kJ/kg·K (0.33 Btu/lb·°F)
@ 240°C (464°F)	DSC	2.18 kJ/kg·K (0.52 Btu/lb·°F)

## EXHIBIT K-2

**Electrical Properties (ASTM Method)**

Dielectric Constant		
1 kHz	D 150	2.3
1 MHz	D 150	2.1
Dissipation Factor		
1 kHz	D 150	0.002
1 MHz	D 150	0.008
Arc Resistance	D 495	143 sec
Volume Resistivity	D 257	$10^{15}$ ohm·cm
Surface Resistivity	D 257	$10^{16}$ ohms/square
Dielectric Strength, Short Time, 500 V/sec rate-of-rise	D 149	17.3 kV/mm (440 V/mil)
Comparative Tracking Index	D 3638	>600 V

**Optical Properties (ASTM Method)**

Haze	D 1003	3.6%
Regular Transmittance	D 1003	77%
Total Transmittance	D 1003	81%

**General Properties (ISO Method)**

Density	ISO 1183	1.20 g/cm <sup>3</sup>
Water Absorption, 24 h immersion	ISO 62	0.13%

**Mechanical Properties (ISO Method)**

Tensile Stress @ Yield	ISO 527	56 MPa
Tensile Stress @ Break	ISO 527	56 MPa
Elongation @ Yield	ISO 527	5.4%
Elongation @ Break	ISO 527	130%
Flexural Modulus	ISO 178	2100 MPa
Flexural Yield Strength	ISO 178	81 MPa
Izod Impact Strength, Notched		
@ 23°C	ISO 180	10 kJ/m <sup>2</sup>
@ -40°C	ISO 180	8.3 kJ/m <sup>2</sup>
Impact Resistance (Puncture), Energy @ Max. Load		
@ 23°C	ISO 6603-2	19 J
@ -40°C	ISO 6603-2	23 J

**Thermal Properties (ISO Method)**

Deflection Temperature		
@ 0.45 MPa	ISO 75	103°C
@ 1.80 MPa	ISO 75	90°C
Vicat Softening Temperature		
@ 1 kg load	ISO 306	118°C
	ISO 306	110°C



EXHIBIT L



March 18, 2003

Attention: Jim Rauh  
Joe Rauh

Subject: *CHEMICAL COMPOSITION OF LG CHEMICAL SA-919 & SA-927*

The chemical composition of SA-919 is as follows:

40.0% Acrylate Rubber  
12.5% Acrylonitrile  
47.5% Styrene

The chemical composition of SA-927 is as follows:

50.0% Acrylate Rubber  
12.5% Acrylonitrile  
37.5% Styrene

I hope that the above information helps you in your projects.

Sincerely,

S. Blazey  
FILE: ENGINEERED PLASTICS-6

EXHIBIT M



March 18, 2003

Attention: Jim Rauh  
Joe Rauh

Subject: *CHEMICAL COMPOSITION OF MUX G*

The chemical composition of MUX G is as follows:

43% Acrylate Rubber  
7% Silicone Rubber  
12% Acrylonitrile  
38% Styrene

I am still getting the information on the SA-919 acrylic impact modifier from LG Chemical. I have called again and am waiting for an answer. As soon as I get it I will forward the information to you.

Sincerely,

A handwritten signature in black ink, appearing to be "S. Blazey", written in a cursive style.

S. Blazey

EXHIBIT O

NOTCHED IZOD

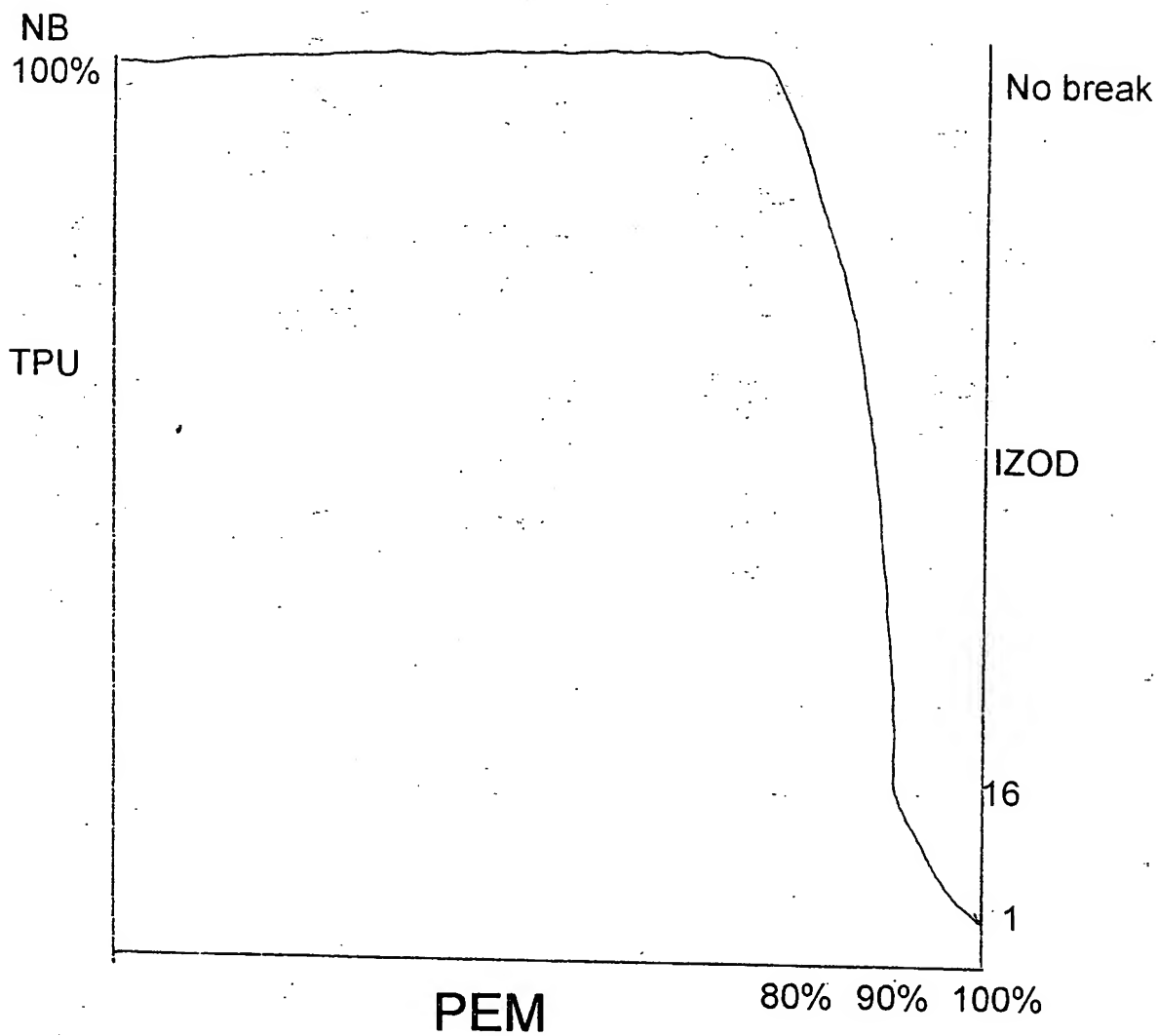


EXHIBIT P

TENSILE

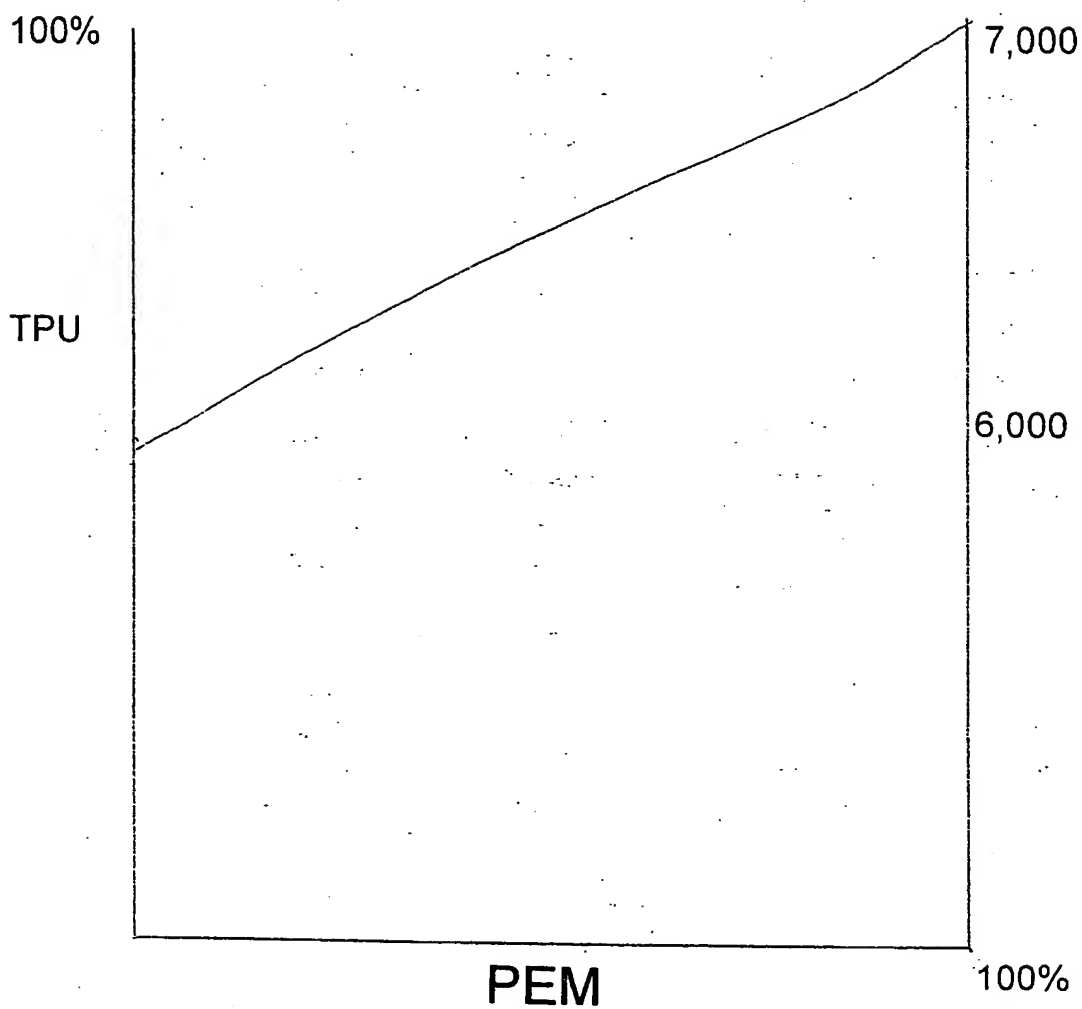


EXHIBIT Q

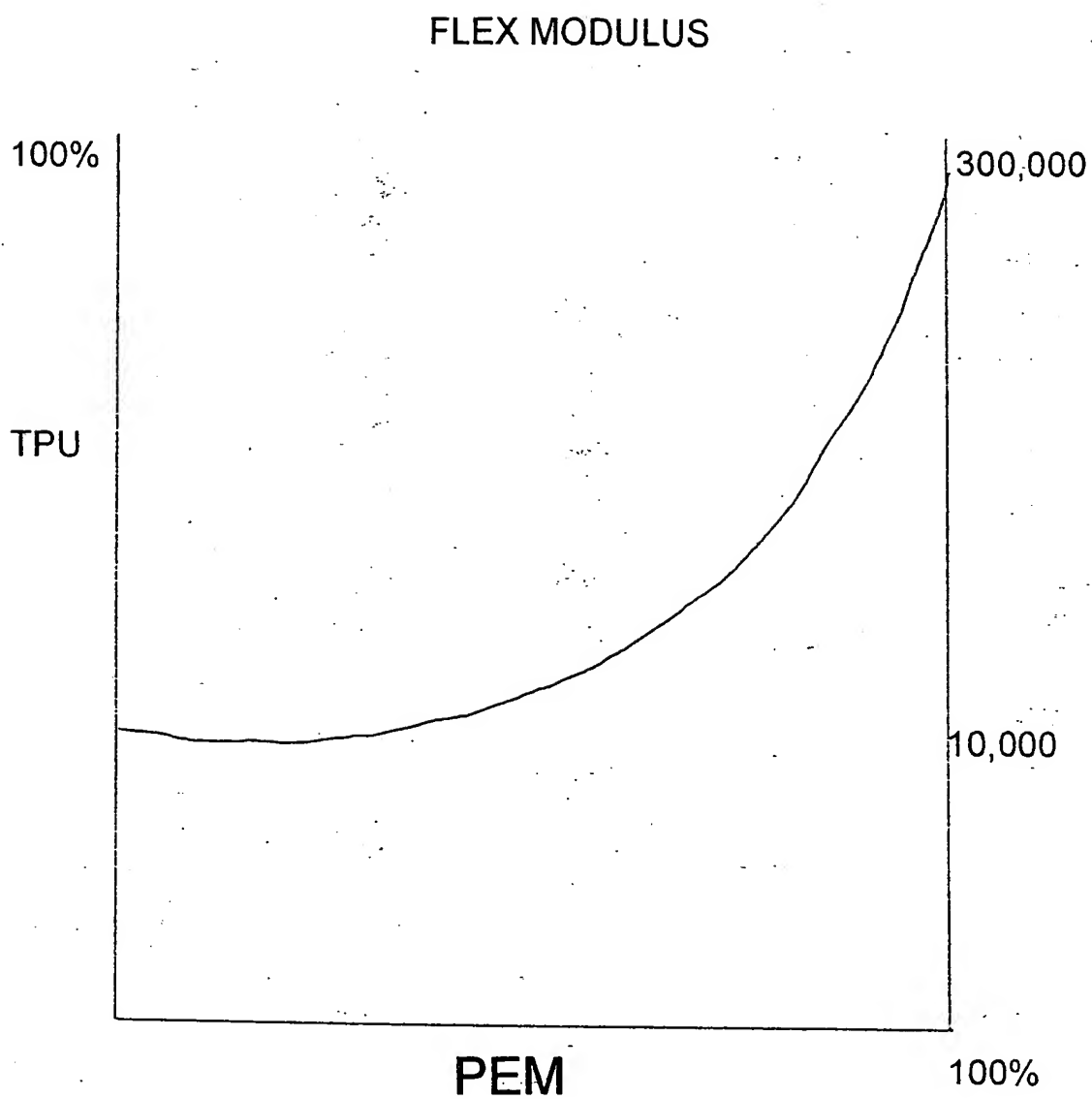


EXHIBIT R

ELONGATION

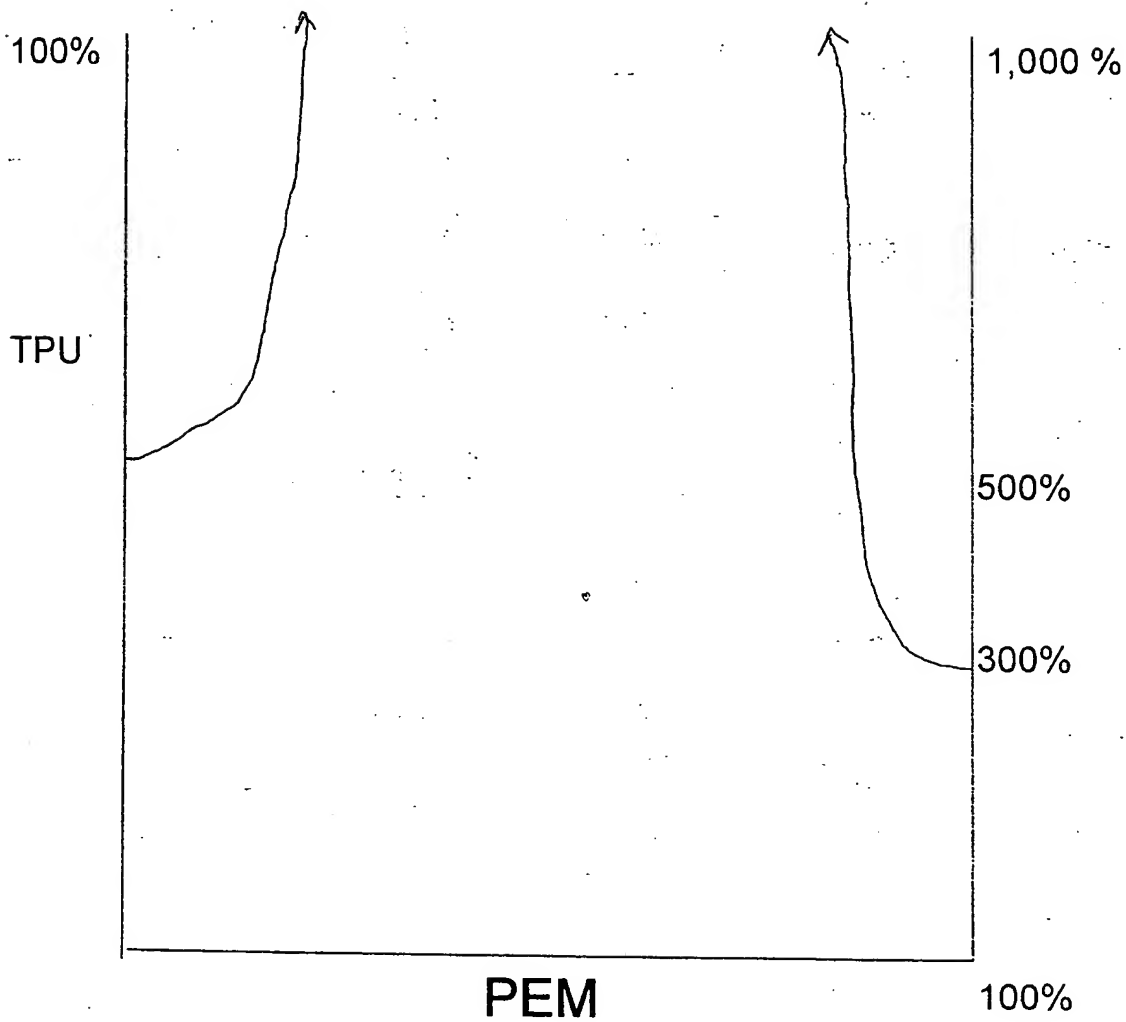


EXHIBIT S

COMPRESSION SET

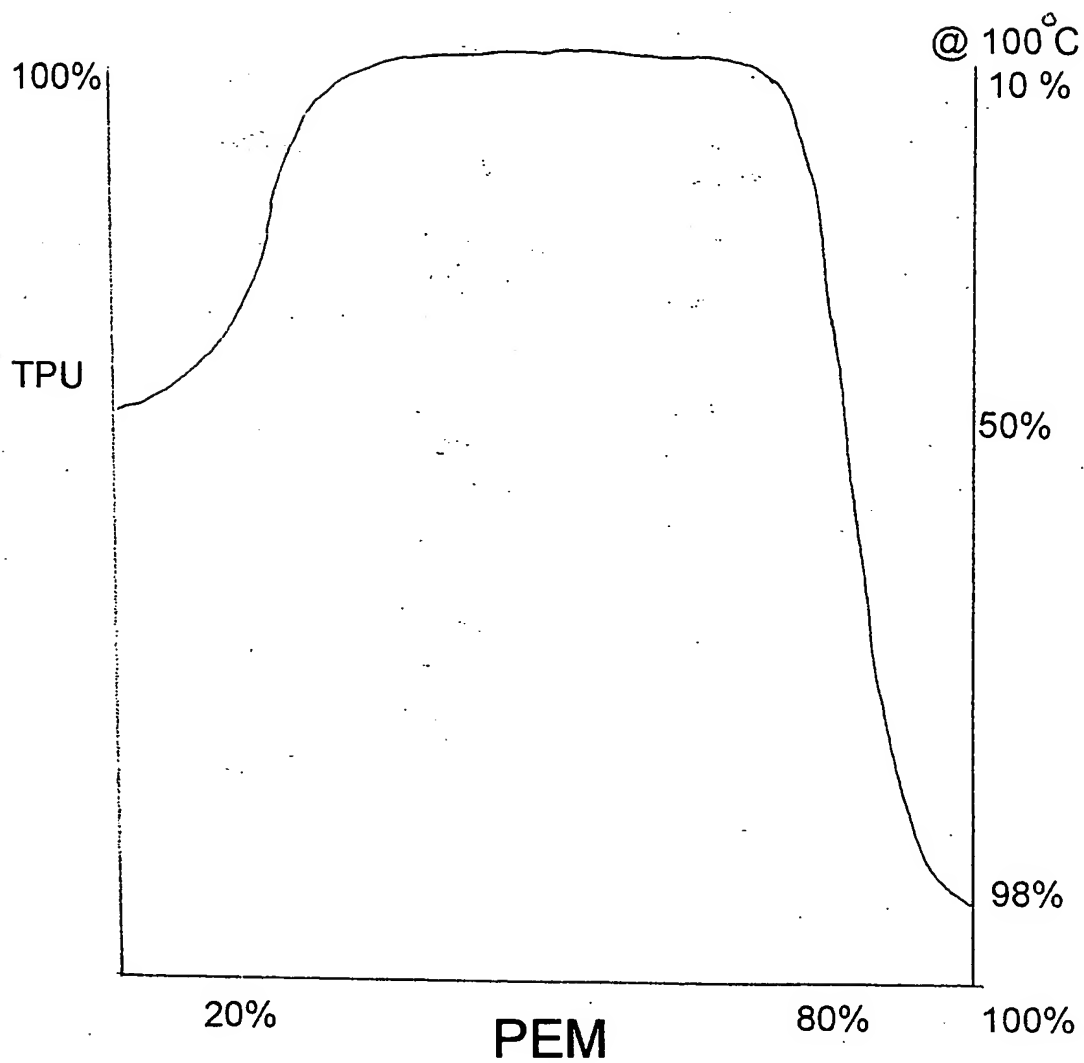


EXHIBIT T

HEAT RESISTANCE

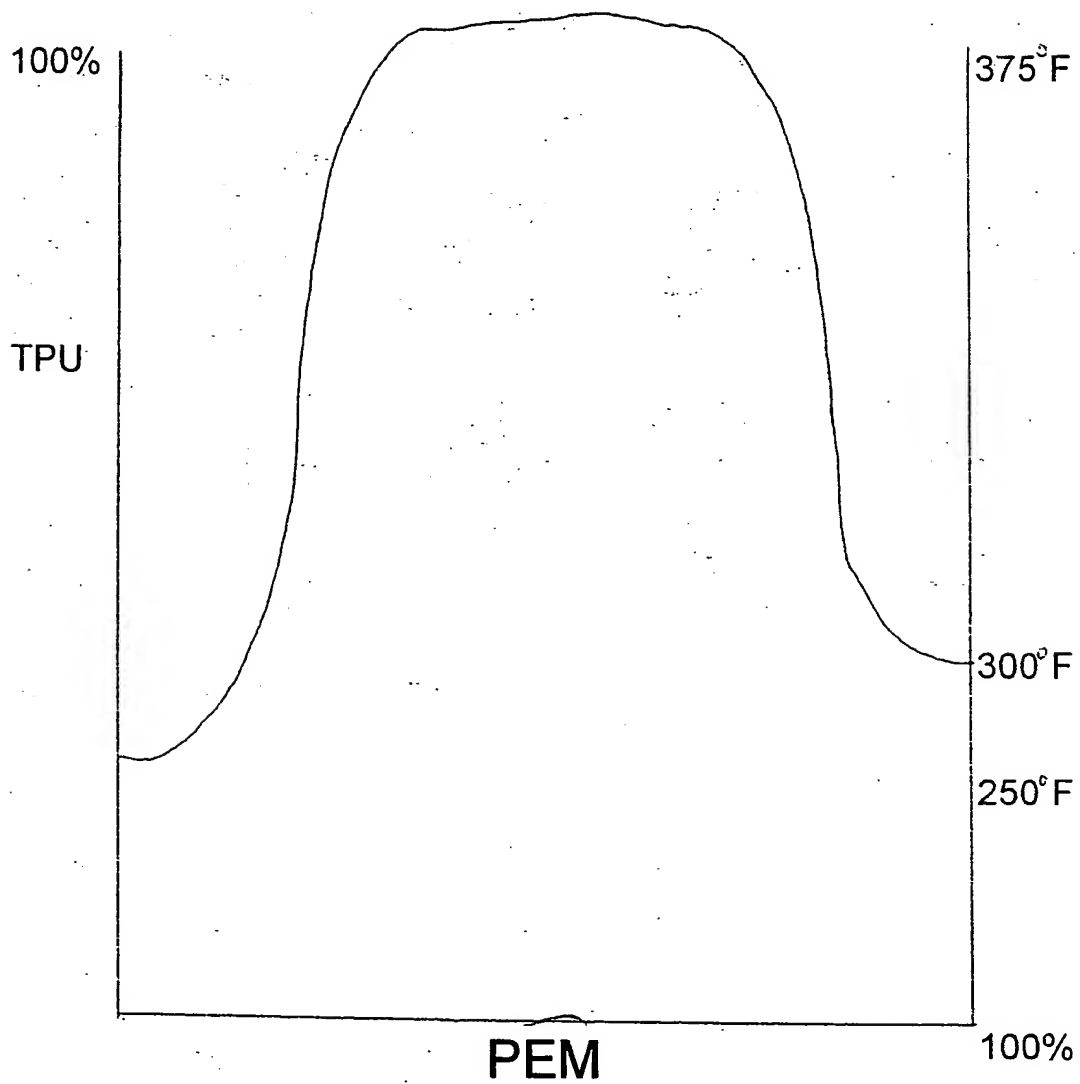
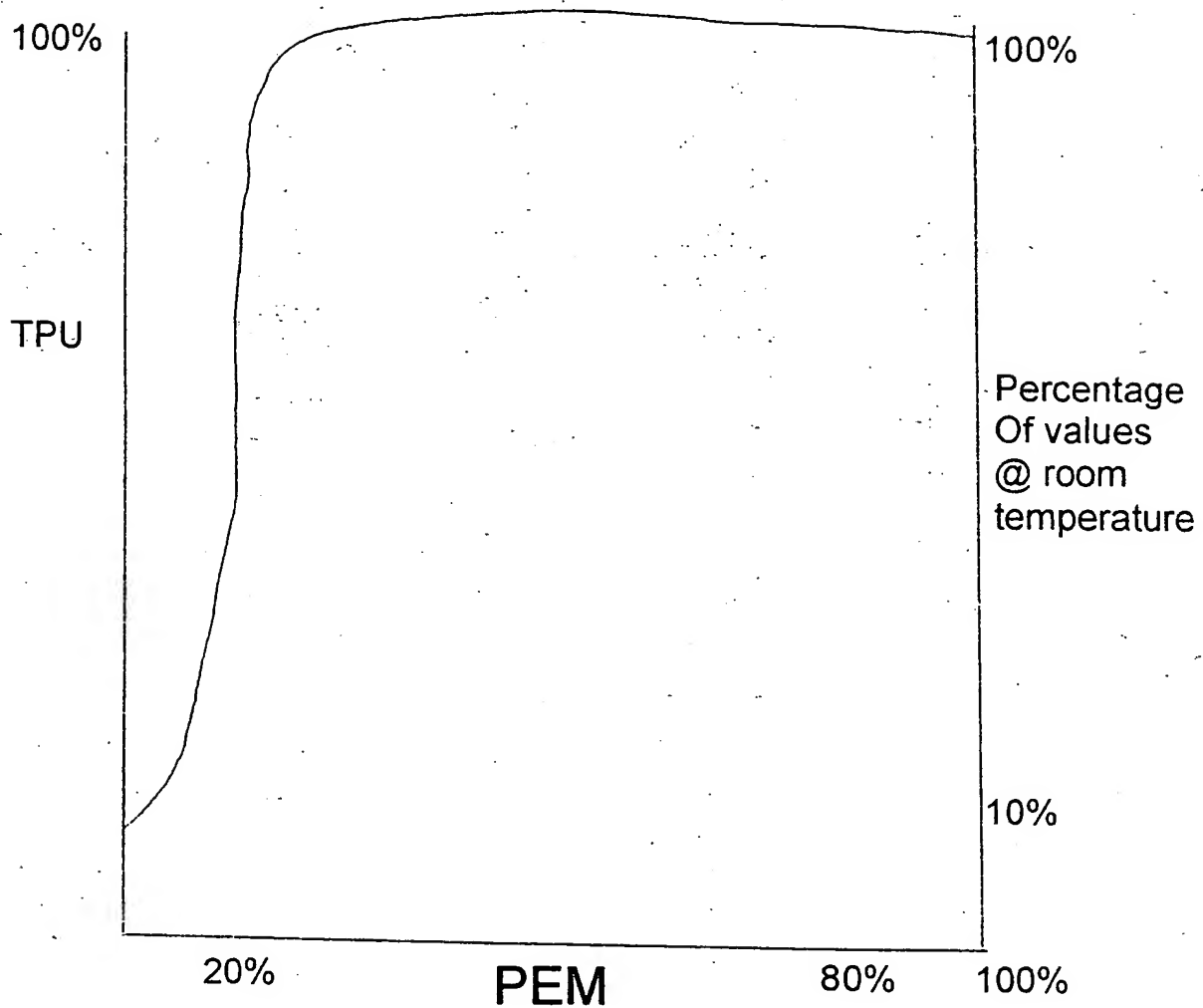




EXHIBIT U

COLD RESISTANCE,  
TENSILE, ELONGATION, & IZOD @ -40 F





**ENGINEERED  
PLASTICS  
CORPORATION**

## PermaFlex 57

Typical Property Values	Conditions	Test Method ASTM/Other	Units	PERMAFLEX VALUE	
<b>Physical</b>					
Melt Flow Rate	230° C @ 2.16 kg	D 1238	g/10 minutes	35	
	240° C @ 2.16 kg	D 1238	g/10 minutes		
Mold Shrinkage		D 955	in / in		
<b>Mechanical</b>					
Izod Impact Strength	Notched	D 256	ft-lb/in		
-40° C				NO BREAK	
73° F				NO BREAK	
Tensile Strength at Break	Type 1 Bar	D 638	psi		
-40° C				6,000	
73° F				6,000	
Tensile Elongation at Break	Type 1 Bar	D 638	%		
-40° C				750%	
73° F				750%	
Heat Aging	168 hours @ 150° C			NO CHANGE	
Melt Point				425° F	
Specific Gravity		D-792	Unit g/ccm	1.25	
Duro Type D		D-2240		57	
<b>Other</b>					
HYDROLYTIC STABILITY				EXCELLENT	
CHEMICAL RESISTANCE				EXCELLENT	
ABRASION RESISTANCE				EXCELLENT	
CUT RESISTANCE				EXCELLENT	
COMPRESSION				EXCELLENT	

The data listed here falls within normal range of properties, but they should not be used for setting specific limits or used as a basis for design. The applications and conditions for use of this product including technical assistance and information are beyond our control. Users of this product are responsible for evaluating this product to ensure their own satisfaction that it is suitable for their intended uses. All information is given without warranty or guarantee. Before working with this product, users must read and familiarize themselves with the available health, safety and environmental information that is available regarding product hazards, proper use and handling.